THE STORED POWER OF THE WORLD.

BY PROF. EDWARD ORTON.

I ask your attention this evening to some considerations upon the *stored power of the world*, with special reference to those forms of it that may be called *fossil power*. I shall also ask you to note the relations of this *fossil power to the increase of wealth among men.*

Force, as defined by the physicist, is anything which *produces, changes* or *destroys* motion in matter. The movement of matter is its chief exponent and result. At root, probably all force is one, but we divide its different manifestations into what are called the forces of nature.

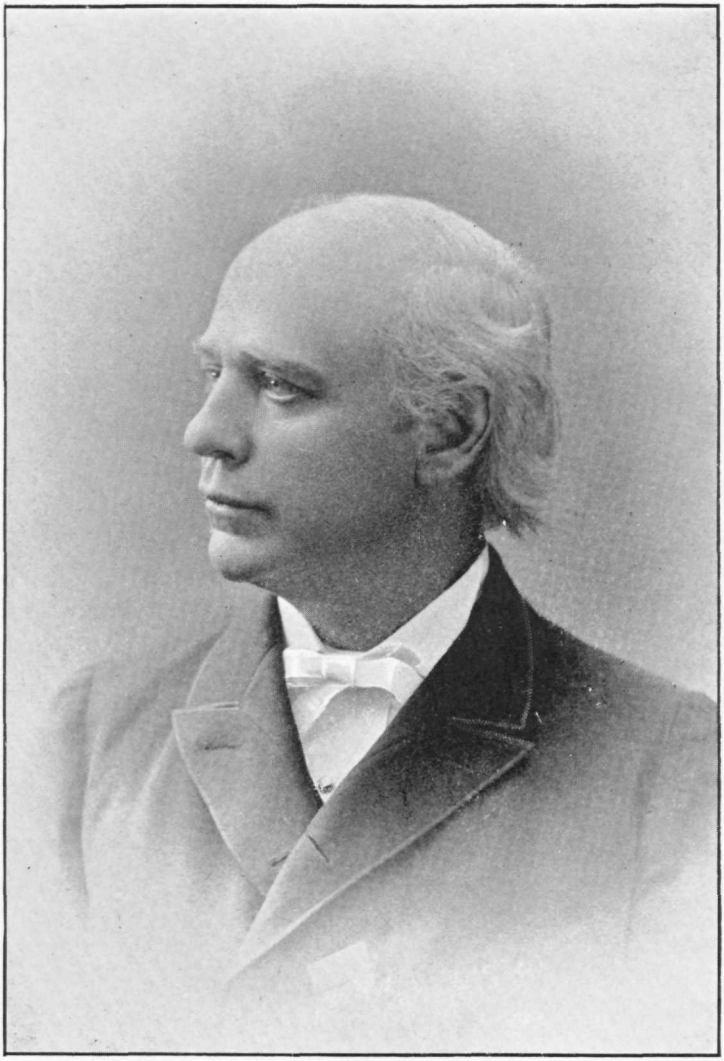
How many, and what are they? I will not attempt a careful enumeration. Gravitation, heat, light, electricity, chemical and vital force will occur to all as leading representatives.

All that I wish in connection with this enumeration is to recall to your minds the great generalization of science that *all the force that is in the world, available for man's use, is derived from the sun.*

To this statement there is but a single exception, and that an insignificant one. There are causes of motion in the world, it is true, that are independent of the sun's agency. "The volcano's red glare, its bombs bursting in air," the jar and shiver of the terrestrial arch when broken by the earthquake shock, these are exhibitions of force that have another origin, but you will observe that they are not directly tributary to the service of man. On the contrary, they bring wreck and ruin in their immediate train. The single exception of serviceable force above noted is found in the tide. We arrest and detain by dams and gates some little portion of the sea when it rises highest upon the land. By opening the gates when the tide turns, we have a head of water that can for a few hours turn wheels, grind grain, saw lumber, and execute other like offices. This force is, however, limited to a very small portion of the earth's surface, and is of small account at the best.

But every other form of force that men utilize, is, as I have said, directly or indirectly referable to the sun.

The *wind* is one of the natural forces that men learned to use long ago in their migrations and their mechanical work, but,



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as every one knows, it is the heat of the sun that is the cause of every movement in the atmosphere. The entire power of the winds is borrowed directly from the sun. Cut off his rays and, as Byron saw, in his dream that was not all a dream, "the winds would wither in the stagnant air."

The force of *running water*, applied also to transportation and mechanical work, has been of larger service than the force of the wind. What gives to running water its force? It is gravitation, you say, as the water descends the mountain side or the continental slope, to the sea. But how came the water upon the mountain side or the continental slope? Every drop that we find above the ocean level was lifted from the great reservoir by the heat of the sun and wafted to its present destination by winds that have the same origin.

The dew, the rain, the rivulet, the river, the lake, each and all, owe all their stocks to the sun. So also the ocean currents, "those rivers of the sea, that know no floods, that fear no droughts," whatever explanation of their flow we may accept, must be mainly ascribed to the sun's heat.

But the earliest force that man learned to use in the improvement of his condition, was the *power of muscle*. To the power of his own muscle, he early learned to add the patient strength of the animals that he was able to subdue. There were many centuries and milleniums in the morning of the world, in which all human well-being and progress were mainly dependent on the exercise of muscular force alone.

From what source is muscular power derived? The animal world, I reply, is in the last analysis wholly dependent on the vegetable world. And the vegetable world is, in warp and woof, the direct product of the sun's rays. All living force must be traced back to the sun.

But, you suggest, the *great* powers, those that are making over the world, still remain to be named, *steam* and *electricity*. You are right. The steam engine lies at the bottom of by far the greatest industrial and economic revolution through which the race has ever passed, and steam is now being re-enforced by the new motor from which we justly expect so much. Do not these forces of the modern world come from a new source? By no means. It is the sun's power that works in and originates both. The changing of water into steam is the work of fuel, and fuel is always organic in its origin, and as for electricity, every current that we can utilize takes its rise either in motion produced by steam or in the chemical changes of certain elements and compounds, all of which are based ultimately on some form of carbon derived from the vegetable world.

It is needless to pursue the enumeration further. I repeat what I have already said, viz.: Every force that can serve the needs of men can be found, by an adequate analysis, emanating from the sun, "of this great world both eye and soul."

How does this power of the sun become available to us? The winds, as we know, blow where they list; the rains perpetually feed the springs that run among the hills, but by what process is the solar energy transformed into the power of muscle, steam and electricity?

The process has been already pointed out. The *vegetable kingdom* is the *agent* of *transfer.* To the plant has the all-important office been assigned of *absorbing, appropriating, storing* the power of the sun.

But in what way does the plant accomplish the surprising work of storing the sun's power? In the new earth which the microscope has created, the most important fact that has been brought to light, is the cell structure of the organic world. Plants and animals alike, from the simplest to the most complex, are wholly composed of cells, invisible to the unaided eye, but carrying within them all the mystery of life.

We cannot distinguish by form or size or composition, animal from vegetable cells in the lower forms of either kingdom, but a surprising difference between them nevertheless exists. The vegetable cell can live and multiply itself on air alone, through the agency of the sunlight: the animal cell has no such power.

One of the constant constituents of the atmosphere is carbonic acid, a heavy gas that consists of one atom of the solid carbon combined with two atoms of the gaseous oxygen. The bond that holds these two elements united is indeed a powerful one. We are able to break it in our laboratories, it is true, but it is only by employing the full resources of chemical skill. But, in the vegetable cell, under the sun's light, this bond melts away, like a thread of flax in the furnace flame. The carbon is fixed in the forming tissues of the plant, while the oxygen is restored to the atmosphere, to maintain its vitality.

A certain measure, a definite amount of the sun's force is required to effect this decomposition. All of the force that was employed in breaking this bond, the heat, the light, the chemical power, is now held in these products of growth, in a *potential* state, but it is ready to be given back on appropriate demands, and the self-same light and heat by which the vegetable substance grew, we obtain again when we burn this substance in furnace or grate. This is the sole source of the power of fuel,

and all fuel, or in other words, whatever will burn, has borrowed its power to burn from the sun.

Taken within the animal system, the products of plant growth give to it also the force that they hold imprisoned. They become on this account and in this way, the food, the support of animal life, the sole source of its heat, its activity, in a word, of its vital force. All animal movements, muscular or molecular, that we can see or that we are obliged to infer, through the whole range of the sentient creation, in the insect's wing, in the fin of the fish, in the hardened muscles of the prize fighter's arm, even in the throbbing brain of poet, orator, or sage, in the hours when inspiration rises highest, result alike from, or at least are alike conditioned by this transformed power of the sun.

We thus see the remarkable office of the vegetable cell. It is a storer of power, a reservoir of force, the mediator between the sun, the great fountain of celestial energy, and the animal life of the world. The animal can use no power that has not been directly or indirectly stored in the vegetable cell. This storage is forever going on. Of the vast floods of energy that stream forth unceasingly from the great center of our system, an insignificant fraction is caught by the earth and the other planets as they revolve in their orbits. Of the little fraction that the earth arrests, an equally insignificant part is used directly in plant growth. But the entire productive force of the living world, turns, as we have seen, on this insignificant fraction of an insignificant fraction.

How long must this force be stored before it is available? It is at once ready to be drawn upon. The rays that built up the cells which are used by the animal as food to-day, may have left the sun but a few hours, days, weeks ago. The blade of grass that added to its substance yesterday, the fruit that has ripened within the last week, the grain that was gathered in the last year's harvest, are all alike available as sources of power to the different divisions of the animal world, but whether produced last year or yesterday, all, it must be borne in mind, have alike been *stored.*

Is there any way in which this sun-power can be *permanently* stored on the large scale? Nature, I reply, has devised various ways for retaining and preserving the power which the vegetable cells have accumulated in past years or centuries or ages. Some of these forms of stored power men have long known and valued, but with the really great accumulations, we have but comparatively recently become acquainted.

What are these accumulations? I answer:

1. The *soil* is a storehouse of power. Originally composed of the disintegrated portion of the earth's rocky crust, it has been gradually enriched by the remains of vegetable and animal life. The carbon of the plant, is a durable substance, and blended with the sand and clay, it emeliorates both the physical and the chemical constitution of the soil. Centuries may have been spent in storing a fertile soil with this transformed sun-power.

2. *Forests*, in the second place, are notable examples of stored power. They always stand for centuries of accumulation. Some trees indeed embrace a thousand years in their cycles of growth. What an amount of sun-power is required to build the boll of a full-grown oak! What torrents of energy have been used in fashioning it! But the oak, in all its stately growth, is *air*, moulded and subdued temporarily by the sun's rays, but ready to pass back into the gaseous state again, and bound to restore as it either burns or decays, all the heat by which it grew.

3. *Peat bogs*, again, are similar examples of stored sun-power. Built up of lowlier forms than forests, they still represent in all respects the same great laws of accumulation. Their blackened masses stand for the separation of large amounts of carbon from the air through the agency of the solar ray.

4. The various accumulations of power that have been already noted shrink, however, into insignificance when compared with the *coals* and the *carbonaceous shales* of the geological scale, and which represent the forests, peat bogs and sargasso seas of earlier ages in the earth's history. These are the *great* accumulations of power. Taking their place as they do, in orderly fashion, among the stratified deposits of the earth's crust, and going back in many instances to a high antiquity, we name them rightly *fossil power*.

We can trace the processes by which these deposits grew. We know the place in the vegetable kingdom of the plants from which the coal seams for example, are derived. The port and bearing of these ancient trees are in our mind's eye, we know their roots, their stems, their wood, their leaves, their flowers, their fruits, but when we come to measure the time spent in these ac umulations, the imagination grows dizzy and shrinks back from the awful chasm of the past. "The ages come and go, the centuries pass as years." A foot of coal requires for its origin the patient growth and slow decay of a hundred of these old-time forests. It was, here as elsewhere, only the remnant that was saved, the remnant of a vegetation that covered the land with a wealth of verdure, that has perhaps never been equaled since. For milleniums of milleniums, we are sure, the sun poured down his potent floods of light and heat upon these carboniferous

savannas. The light and heat were absorbed there in the processes of plant growth, were locked up in leaf and stem and spore, were buried beneath the sediments of an advancing sea, were converted at last into stone, became a part of the earth's crust, but still retaining their original nature, still containing, literally and truly, the light and heat, the *power*, of the long ages of the early world in which they had their birth.

5. One other form of fossil power remains to be noted, known in some of its phases to the earliest antiquity and utilized in the walls of Babylon, in the cradle of Moses, and even in Noah's ark, but for the first time in our own day, becoming an important factor in the light and heat supply of the civilized world. I refer of course to the bitumens, under which gas, petroleum, mineral tar and asphalt are found. This series also stands for sun power, but it has suffered a greater transformation than the forms of stored force already considered. All the steps of the transformation can, however, be followed, and petroleum and its derivatives unquestionably belong in the same category with coal.

The bituminous series has a vast aggregate, vast beyond the most extravagant estimates, I am persuaded. There is scarcely a foot of the limestones and shales that constitute so large a part of the entire geological column that does not contain, if unaltered by metamorphic heat, in notable quantity, some one of the bituminous elements, but though the *aggregate* is vast, the *utilizable stocks* are very much restricted. The accumulations of oil and gas in the large way depend upon the exceptional arrangement of the rocks that contain them. It is a happy accident that gives rise to an oil field or a gas field in any series, even though the rocks of the series may be saturated with both oil and gas. The substances of this last named group have awakened an extraordinary interest in many parts of the world during the last few decades. This interest arises from the fact that in their exploitation, many of the elements that give such a fascination to the search for the precious metals are found, viz.: small risks and great rewards. This entire bituminous series is, however, of small account when compared with the other form of stored power, viz.: coal. The vast sheets of this later mineral, arranged in an orderly way and admitting of an economical and persistent development, are intrinsically the most valuable and, at the same time, the least appreciated forms of wealth with which the crust of the earth is stored.

I have now named the principal permanent repositories of thestored sun power of the world, viz.: soils, forests, peat bogs, coal beds, oil, gas and asphalt. What value do we set upon

them? Do we find that they increase the supply of the necessities, the comforts or the luxuries of life? Assuredly we do. Life becomes very scant and bare when all the force it can command is derived from the seasons as they roll. Under such circumstances, the accumulation of wealth becomes difficult if not impossible, and where the possibility of the accumulation of wealth is lost, much, yes, most, of all that gives dignity and beauty to life goes with it. There are considerable sections of the human race that are already in this condition, living from hand to mouth, born in abject poverty, escape from which is simply impossible.

The stored power of the *soil* is, of course, the first to be recognized and appreciated by men. As soon as they emerge from savagery and begin to have fixed bounds for their habitations, they necessarily learn the value of fertile soils—soils made fertile by the addition of materials incorporating some of the energy of the solar rays of the past years or generations. The migrations of men in all ages have largely or chiefly been in quest of more productive soils. All the early civilizations were established on alluvial plains where the stored power on which fertility depends was at once the most abundant and the most available. India, Egypt, Babylon, are examples. The soil, in fact, is the only form of stored power that men learned to value until recent times.

The *forests*, for example, repelled and obstructed them in all the early ages. The great wealth stored in their noble growths entailed additional labor and outlay upon those who were called to subdue and occupy such tracts.

The fossil power stored in *coal* began to be turned to some small account in England several hundred years ago, but there were only a few districts in the kingdom that could readily avail themselves of the new found supplies. The impossibility of transporting coal on the large scale forbade any general development of it. Only those mining regions that could find water carriage for their product, and only the towns that were well situated in the same regard, could make use of it to any considerable extent.

The truth is that all the great applications of the stored power of the world, belong to the 19th century, and the most important of them belong to the last fifty years. What has been done within this century, constitutes by far the most important chapter in the economic history of the race. *Fossil power* lies at the root and center of this unparalleled advance.

How was the great development brought about? It is connected, I reply, in a most intimate and important way with a

single invention, viz.: the steam engine, the like of which as an agent of revolution, the world has never before seen. When there is added its application to locomotion, the whole story is set before us. But the steam engine in all its forms is conditioned by and absolutely dependent upon the fossil fuels to which I have already referred. The forests of all the continents would, under its exorbitant demands, melt away like dew before the rising sun. In large portions of the world and even in those, as England, where steam power has wrought its greatest marvels and triumphs, it would be simply impossible to use it in any large way were it not for the vast stocks of sun-power that were stored away in the geological series during the earliest ages of the earth's history.

There are, in particular, two great lines of service rendered by this revolutionary machine. They are found in manufactures and in transportation. These lines blend with each other, it is true, but we can, with advantage, consider them separately.

In *manufactures*, the steam engine supplies power wherever it is wanted and just as much as is wanted. Before its advent, men were sharply restricted in their use of power. They were limited to fitful winds, to streams that were forever alternating between floods and shoals, to tides that can work but an hour or two at a time, and to the power of muscle. The restriction applied not only to the amount, but also to the location of the available power, but the steam engine has changed all this. It brings to any desired point the energy that is required for the most gigantic and the most varied tasks, from forging the shaft of an ocean steamer to weaving tissues of gossamer. The removal of the restrictions of the older time has exerted a powerful stimulus on the inventive faculties of men. The assurance that a power is at hand ready to drive, without rest or weariness, machinery of any strength, of any complication and for any purpose, has led to covering the whole field of the material wants of man with the most ingenious machines for supplying these wants. How little in the way of manufactures is done by hand! How miraculously the products of skill are multiplied! The world cannot take up in any field the possible products of the machinery that we have devised. Production is on this account forever overrunning any possible demand.

At the bottom of all this wonderful and on the whole, beneficent activity, lies coal, the great representative of the fossil power of the world. It is coal that turns every wheel, lifts every lever, strikes every blow. In Great Britain alone, coal does the work of more than 100,000,000 men. It adds to the wealth of these fortunate islands on this basis.

In *transportation*, steam has brought about a still more wonderful change. The civilized world with all its belongings, I might almost say, the whole human race, has been mobilized by means of its application to locomotion. The oceans have dwindled to straits. Through the inmost recesses of the great continents we now pass backward and forward with perfect freedom and comfort, and all the exchanges of commerce go with us, for this mobilization of man applies as well to all the objects which he values as to himself.

The sun-power that does all this work has been buried in the earth's crust for many millions years. The steamer that crosses the Atlantic in six days burns a ton of coal for every mile. The locomotive that races over the plains or climbs the continental divide owes every inch of its advancement and its ascent to coal. Coal drives the pick that undermines the seam in which it itself lies: the drill, that prepares it for the blast; pumps the water that would otherwise drown the mine; lifts itself from the deep pits where men find it; transports itself over land and sea. It gives value at the same time to all other forms of power and all other sources of wealth, to soils, to forests, to mines. What would be the value of a bushel of wheat in Dakota, of a bullock in Montana, of a pine tree in Wisconsin or Georgia, of a mineral lode in Nevada or Colorado, without railroads and steamboat lines?

We must note, in passing, some further consequences of the discovery and use of fossil power on the large scale. We shall find the most striking characteristics of our day and age, so far as the material side of life is concerned, centering around this one element. What are these characteristics of the nineteenth century? There are no more distinctive features of our time than the two following, viz.: the *remarkable growth of cities throughout the civilized world*, and the *unparalleled increase of the wealth of men*. Both take their rise in coal, both are conditioned by its use in all their phases and stages. It is not necessary to repeat the statistics of the growth of cities in the nineteenth century. There is nothing like it in the previous annals of the race. The percentages of increase no longer read by the tens or scores, but by the hundreds and thousands.

What has led to this amazing expansion of city life, now for the first time in history? Has the social instinct that draws men into urban communities been suddenly awakened? This instinct has been active from the beginning; men have always been building cities, but heretofore such communities have been held strictly in check by the problems of food and fuel supply. In our century, these limitations have all been swept away. The

cheerful optimist who found proof of a wise and kindly providence in the fact that great rivers are always to be found near great cities, would be staggered by the phenomena of our day. Great cities are now sometimes built on small rivers or hundreds of miles from any. We build in fact where we will and as large as we will, for the resources of the modern world can be made tributary to any designated point.

It goes without saying that all of this growth is based on steam transportation and this in turn rests absolutely on the potential energy of coal. Every city has a coal mine underneath it that warms and lights and feeds and clothes its gathering thousands, or if not directly underneath, still tributary to it and connected with it by an iron roadway or a steamship line, or by a score of both. Cut off this supply of fossil power and the city wilts and withers like a branch severed from the parent stock. But for the growth of the modern town, you say manufactures are largely responsible. Yes, but all modern manufactures are absolutely dependent on the stored force of coal. Machinery driven by this power, is everywhere replacing the skilled labor of the olden time. Cities grow largely by massing the ruder labor that our modern factories can utilize.

With this growth of cities in the modern world, a group of problems arises, all of which are new and of which we are obliged to work out the solutions. No other problems of equal gravity and urgency confront the statesman, philosopher or philanthropist of our day. All of them have their root in coal.

2. A second consequence of the utilization of fossil power on the great scale is found in the *unparalleled increase* of wealth among men by which the nineteenth century is characterized and in the phenomenal growth of individual fortunes. In no century of the past has there ever been any close approximation to these features of our own time. Since the year 1800, the total wealth of Great Britain has been more than doubled. In other words, the nineteenth century has already overbalanced all the previous centuries of its long history. Similar facts obtain in all progressive nations, *in proportion to their utilization of fossil power*. The increase of wealth in the United States during the present century, is vast beyond all expression or conception.

Never before has such extreme inequality prevailed in the distribution of wealth as in this country. The individual fortunes of our day, mainly gathered in the last forty years, overtop all that have been known before and render the standards of comparison which the world has used for the last 2000 years, ridiculously inadequate. Think of it. An upstart Stewart, Vanderbilt or Gould gathers in half a single lifetime more millions

than the royal families of Europe have accumulated in a thousand years, by all the arts that they have learned to practice.

What is the meaning of these facts? Has the heart of man been for the first time smitten by the love of gain? Not at all. The "*auri sacra fames*" of the Latin poet is older than Jason, But there *is* an element that is new. A new agent of accumulation has been put into our hands. We have found the key to buried treasures, treasures rich beyond the wildest fancies of any Arabian dreamer. It is not simply "another morn risen on mid-noon." A thousand summers burn and glow in one of ours. They bring to us all their light, their heat, their wealth-producing force. They lengthen our lives and increase our powers of accumulation on this same scale. More years serve each one of us, an hundred-fold, than the antediluvian patriarchs enjoyed, if we should accept all that the record gives to them. In comparison with the centuries and milleniums that are made to pay tribute to a Vanderbilt or Gould, Methuselah died in infancy.

This is the secret of the amazing increase of wealth in our day, and of the alarming inequality of its distribution, viz.: the control that we are for the first time acquiring of the stored power of the world, by means of which the efficiency of every wealth-producing agency has been multiplied ten, twenty, a hundred or a thousand fold. We see the rich growing richer, and perhaps, the poor growing poorer, and looking around for a cause, if inclined to politics, we ascribe the results to the policy of the country with respect to protection or free-trade, forgetting that similar results are to be found under either policy. It is not the tariff, it is not the absence of a tariff, that is responsible for the conditions which all deplore. It is the steam engine, it is the coal which feeds it. A pound of good coal used in a good engine, stands for the work of six horses for an hour; a ton of coal, for the work of 1300 horses for a day of ten hours. Job was counted rich in the time of his prosperity, but it would be a very humble manufactory to-day that could not discount, in the power that it employs, all his live stock. What shall be said of the factory that consumes 10 tons of coal or 100 tons in a day, or of the railroad magnates whose locomotives use 10,000 tons of coal in a day? 10,000 tons of coal! No wonder they grow rich. Reduce this amount to horse power, and you will see where the millions of Gould and Vanderbilt come from. 10,000 tons of coal stand for the work of 13,000,000 horses, working for ten hours in a day!

When the Duke de Liancourt brought to his royal master at midnight the ominous tidings of the storming of the Bastile, the

King interrupted him, "But this is a revolt." "Sire," said the faithful messenger, "it is not a revolt, it is a revolution."

We are passing through a revolution which we still persist in calling a revolt. We are still busy in putting new wine into old bottles, with the usual result. We are still vainly striving, with the broom of old restrictions, to sweep back the rising tide of nineteenth century wealth from overflowing all our time-honored landmarks.

But the social and political results of these new applications of the stored power of the world pass beyond my domain. There remain, however, one or two points that I must briefly touch in closing my paper. The most important question relates to the duration of the supply of this stored power of the world.

How long will it last? In the current phrases of the street, has the new state of things *come to stay?* Has man entered permanently upon a new era? Shall each to-morrow of a long future be as this day, and still more abundant? Do these new-found stores of power, upon which our astonishing progress is wholly built, exist in large enough amount to meet the ever growing demands of the race for long periods of time, as centuries and milleniums?

The question in reality turns upon the supply of coal. The world's supply of coal, I answer, is large, but it is far from being without limit. The territory that holds it is measurable in square miles. The contents of the coal seams are measurable in tons. The first measurement, that of territory, we have already approximately made. There are about 400,000 square miles of the earth's surface known to be underlaid with coal. The determination of the tonnage of any field is much more difficult, but it has been attempted in England and on a smaller scale in Pennsylvania and Ohio. The figures derived from one field, however, have no necessary relation to any other.

The coal of the world is mainly held by the English-speaking nations. The United States and the United Kingdom head the list, and the countries that stand next are separated by long intervals.

For a third of a century, the "coal question" has held a leading place in Great Britain. No intelligent Englishman fails to understand that the manufacturing and commercial supremacy of his country is absolutely dependent on its stores of fossil power. How long will English coal hold out? Professor Hull opened the discussion in 1860. He calculated that at the rate of use then prevailing, the coal fields of the country would last 1000 years, but as the rate of use would be constantly increasing, the duration would be correspondingly reduced. Hull's figures

and conclusions were presently reviewed by Prof. W. S. Jevons, and a surprisingly different result was reached. He gave to British coal a life of but 100 years. These startling figures awakened a universal interest in the question, and as a result, a parliamentary commission was appointed in 1866 to make a careful study of the facts and to report. It made the examination and in due time announced its results. The coal fields would last somewhere between 324 and 433 years. But in the twenty-five years that have passed since the work of the commission was finished, it has been found that the rate of increase of output of the mines is considerably larger than that assumed by it. Furthermore, the new facts reduce the tonnage below the estimates of the commission and conservative engineers are now disposed to revert to Professor Jevons's figures as nearest the truth, or in other words, they hold that the twentieth century will see the end of coal mining on the large scale in the British Islands.

What will be the condition of the coal fields of the United States at the end of the next century? Our coal supply, I reply, has been greatly overrated. The area of our coal territory is magnificent, but its tonnage by no means corresponds. To apply the tonnage rate of England to the coal area of the United States is misleading to the last degree. England's 6000 square miles undoubtedly contain more coal than 60,000 square miles that could be located within our coal territory.

By the end of the first quarter of the century most of our smaller fields, the Hocking Valley among the rest, will have been exhausted. The middle of the century will see the end of the anthracite field of Pennsylvania, the most remarkable and valuable single body of fuel yet found on the planet.

From this time forward, viz.: from 1950, the main demand of the eastern and central United States for fuel, light, power, metallurgical work, railway and steamship supply will fall with undivided weight on the great Pittsburgh coal seam. How will it bear this ever-increasing draught? While fifty years will not by any means exhaust it, it is yet plain to be seen that by the end of the twentieth century, there will be a "coal question" in the United States more urgent by far than the coal question of the United Kingdom at the present time.

What of petroleum and natural gas in the twentieth century? Both will have "gone glimmering" in its early decades. Their modern history began after the middle of the nineteenth century. In the light of present knowledge, it seems probable that each will have run its meteoric race before the middle of the twentieth century. I speak of the supplies that are now being exploited in the continents of civilization.

Nothing is clearer than that the world cannot long maintain, cannot maintain for many centuries, at the longest limit, the lavish use of stored power which has flooded with unheard-of wealth the latter half of the nineteenth century.

I have carried you far enough already, viz.: to the year of grace, 2000. I will not venture beyond. I meant to have spoken at some length of the reckless waste that we are making of the precious stores of power to which we have found access, but my time forbids. The nineteenth century will have a bad pre-eminence in the future history of the race for the wholesale destruction of that which not enriches it, but makes the coming ages poor indeed. Of the coal burned as fuel we utilize less than one-half of the heat, of the coal burned for power, we utilize not more than one-tenth.

A single question remains. *After coal, what?* When the great stocks are materially reduced, when we can no longer use them freely, how will men fare, how will life go? Will the race be obliged to return to the old conditions, give up the freedom of the planet which it now enjoys and forge on through a prolonged and melancholy decadence? Shall

> "The God of Bounds, who sets to seas a shore,
> Come to it, in his fatal rounds and say, 'Alas, no more,
> 'No further spread thy broad ambitious branches nor thy root
> 'Fancy departs, no more invent,
> 'Contract thy firmament to compass of a tent.'"

There are some dreams of science that she hardly dare whisper to herself—that the art of utilizing the power of the sun's rays, *directly* from the vegetable kingdom without the transfer of its force into steam power, or even *without the intervention of the vegetable kingdom* at all, may sometime be discovered, that a key may sometime be found to the great treasure house of unused solar energy that forever invests the earth. If such an art should be discovered, the race would enter upon a new lease of life, and wealth and power, such as eye has not seen nor ear heard nor the heart of man conceived, would be poured into the lap of the future. In comparison, even the nineteenth century would be relegated to the dark ages.

But if no such discovery is made, if man is still obliged to depend upon the vegetable cell for storing all of the heat and power of which he can avail himself, is he certainly doomed to the ever-narrowing circle and the shrunken career? No. Even in such a case, the past could be wonderfully, infinitely improved. Man could be vastly poorer in material things than he

now is, and at the same time, be vastly richer in mental and moral resources. Plain living is not incompatible with high thinking. Life, even though much reduced in its accidents, might still be, a thousand times over, worth living. The sun of science has risen on the world, with healing in its beams—has risen, and will never set. Life can never be mean in a world that it illuminates.

There is one source of supply of human wants, the earliest, the only universal source, and still the crudest and least developed, in which unlimited possibilities of advance and service are found for the race, viz.: the soil. It is here that the sun's power is most easily stored. This, in fact, is the only form of storage that we can thoroughly command and of which we can directly avail ourselves. Occasionally we see, on a small scale, examples of what the soil can be made to render, under wise and patient tillage. Whenever such examples meet us, it is as if a window were thrown open upon a wide and sunny landscape.

A few months ago, in company with a friend,* I drove up at night-fall to a large and lonely pile of buildings, situated among the barren slate knobs of southern central Kentucky. We knocked at a wicket gate and asked for lodging. A key was turned and bolts were drawn, and we stood within the Abbey of Gethsemane, the home of the white-cowled monks of La Trappe, the silent brotherhood. Across that threshold no woman's foot had ever stepped. No voice of childish glee was ever heard within the consecrated precincts. We entered the main building. The rooms were large and high, and though fairly clean were scrupulously free from all that we count the comforts of life. Along the uncarpeted halls and stairways, you could hear from afar the clatter of the home-made shoes of the monk who is summoned to meet the new comers. Father Peter led me in due time to my sleeping room and before he left me, told me the order of the house. As 2 o'clock every morning of the year except Sundays and Saint's days, the faithful begin their worship in the dimly-lighted chapel. From 2 to 5, the time is spent in prayer and meditation, and at 5, a more formal service is celebrated. It was not necessary, the father informed us, for us to rise at 2, but he would call us in time for the 5 o'clock service.

A few rude wood cuts of religious intent adorned the walls of the upper halls and sleeping rooms. Some of them were realistic to a startling degree. Two contrasted scenes, the visitor will not soon forget; the deathbed of the saint, and the death-

* Hon. J. R. Procter, State Geologist of Kentucky, and now Civil Commissioner of the United States.

bed of the sinner. Around the latter, malignant fiends are hovering, with talons extended to seize their prey. The eyes of the dying man have been opened to discern these shapes of terror, and he would fain hide himself from their cruel grasp. The picture was in full keeping with the horrible conceptions of an infernal world of vengeance and torment, which the dark ages evolved and the shadows of which still hang around the benighted corners of Christendom.

At 5, I rose and was guided to the chapel. Manly voices, trained and true, but touched, as it seemed to me, with unspeakable sadness, sent aloft through the high arches, the confessions and petitions of the service in sonorous Latin. I can hear their plaintive cadences yet.

I took my breakfast from an uncovered table, provided with only the rudest wares, but supplied with food that could meet the necessities of the hungry.

I entered the library. I saw but one book that had been written in the nineteenth century. The several alcoves were filled with religious literature to the exclusion of all other, the sermons of the fathers, the lives of saints. The shelves seemed to me to *groan* beneath these burdens of the medieval world.

I visited the burial ground adjoining the chapel, where the departed brethren are laid. The graves are crowded close together; each is marked by a plain wooden head board, containing the name alone of the brother who rests beneath. There is always an open grave for the next comer, a favorite place for meditation.

I was in Europe for those 12 hours. The hand on the dial had been turned back five centuries. The silent monks were living amidst the hopes, the fears, the ideals, the ignorance and superstition of the dark ages.

It was a relief to reach the sunlight once more, to hear the cheerful songs of birds among the embowered homes that God had taught them to build. I entered the noble gardens of the monastery, covering acres in extent, where the brethren toil, early and late, and from which they obtain all the food that they use. The vegetables showed a luxuriant growth. The air was redolent with the delicate fragrance of the blossoming vine, and fruit was reddening on the trees. *Here* had been prayers that God could answer. *Here* had been an appeal to nature that she is never slow to honor. Under the wise and patient husbandry of the monks "the barren wilderness had smiled, with sudden greens and herbage crowned." Thin lands had been taken because they were low-priced, lands far below the average of the central counties in quality, lands from which the native farmer

wrests only a scanty living, but a few acres had been made to give a generous support to the entire community, with a large surplus to be disposed of, and *the acres were growing richer every year*.

I could not join the monks in their prayers and confessions. Their penances and self-inflicted flagellations seemed to me altogether unnecessary. Their *heaven*, I am sure, would be no heaven for me, but their little section of the *earth*, I could understand, and with all my heart, I thanked the Silent Brotherhood for the lesson it had taught me, and as I reluctantly turned my back upon the Abbey at last, it seemed to me that mankind, after all, could do a good deal worse for itself than to wind up its course, as it began it, *in a garden*.